CLAIMS

1. A self-doping type electrically conducting polymer comprising crosslinked polymer chains.

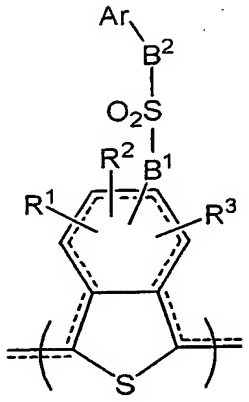
2. The self-doping type electrically conducting polymer as claimed in claim 1, which has a sulfonic acid group.

3. The self-doping type electrically conducting polymer as claimed in claim 1 or 2, wherein the crosslinking is formed through a sulfone bond and the sulfone bond is contained in an amount of from 1 to 90 mol% based on the repeating unit of the polymer.

4. The self-doping type electrically conducting polymer as claimed in any one of claims 1 to 3, wherein the polymer chains are crosslinked through a bond having a binding energy from 0.5 to 2 eV lower than the binding energy of the sulfonic acid group as measured by X-ray photoelectron spectrometry.

5. The self-doping type electrically conducting polymer as claimed in claim 1 or 2, which contains an isothianaphthene skeleton having a sulfonic acid group.

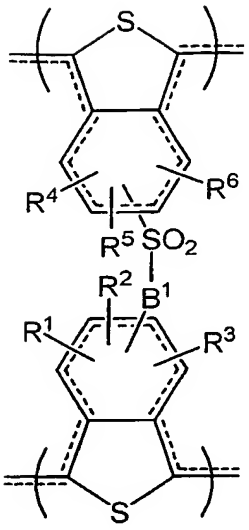
6. The self-doping type electrically conducting polymer as claimed in claim 5, wherein the crosslinked structure through a sulfone bond is a isothianaphthene structure represented by formula (1)



(1)

wherein R^1 to R^3 each independently represents a hydrogen atom, a linear or branched alkyl group having from 1 to 20 carbon atoms, a linear or branched alkoxy group having from 1 to 20 carbon atoms, a linear or branched alkenyl group having from 2 to 20 carbon atoms, a linear or branched alkenyloxy group having from 2 to 20 carbon atoms, a hydroxyl group, a halogen atom, a nitro group, a cyano group, a trihalomethyl group, a phenyl group, a substituted phenyl group or a $-B^1-SO_3^-M^+$ group, B^1 and B^2 each independently represents $-(CH_2)_p-(O)_q-(CH_2)_r-$, p and r each independently represents 0 or an integer of 1 to 3, q represents 0 or 1, Ar represents a monovalent aromatic group, a substituted monovalent aromatic group, a monovalent heterocyclic group or a substituted monovalent heterocyclic group, and M^+ represents a hydrogen ion, an alkali metal ion or a quaternary ammonium ion.

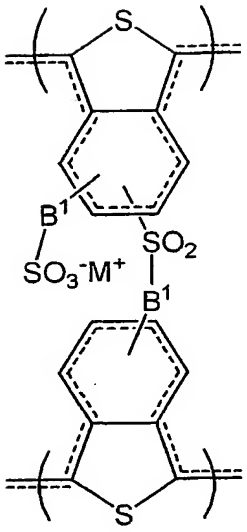
7. The self-doping type electrically conducting polymer as claimed in claim 6, wherein the crosslinked structure through a sulfone bond is a structure represented by formula (2):



(2)

wherein R^1 to R^6 each independently represents a hydrogen atom, a linear or branched alkyl group having from 1 to 20 carbon atoms, a linear or branched alkoxy group having from 1 to 20 carbon atoms, a linear or branched alkenyl group having from 2 to 20 carbon atoms, a linear or branched alkenyloxy group having from 2 to 20 carbon atoms, a hydroxyl group, a halogen atom, a nitro group, a cyano group, a trihalomethyl group, a phenyl group, a substituted phenyl group or a $-B^1-SO_3^-M^+$ group, B^1 represents $-(CH_2)_p-(O)_q-(CH_2)_r-$, p and r each independently represents 0 or an integer of 1 to 3, q represents 0 or 1, and M^+ represents a hydrogen ion, an alkali metal ion or a quaternary ammonium ion.

8. The self-doping type electrically conducting polymer as claimed in claim 7, wherein the crosslinked structure through a sulfone bond is a structure represented by formula (3)

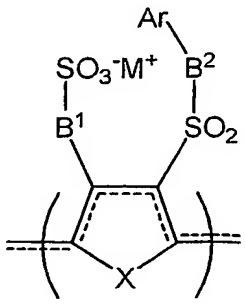


(3)

wherein B^1 represents $-(CH_2)_p-(O)_q-(CH_2)_r-$, p and r each independently represents 0 or an integer of 1 to 3, q represents 0 or 1, and M^+ represents a hydrogen ion, an alkali metal ion or a quaternary ammonium ion.

9. The self-doping type electrically conducting polymer as claimed in any one of claims 2 to 4, which contains a heterocyclic 5-membered ring skeleton having a sulfonic acid group.

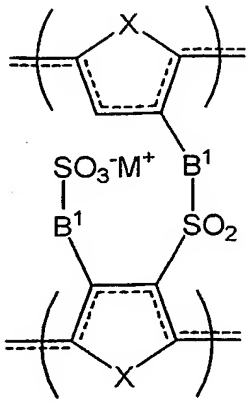
10. The self-doping type electrically conducting polymer as claimed in claim 9, wherein the crosslinked structure through a sulfone bond contains a structure represented by formula (4)



(4)

wherein X represents -S-, -O- or -N(-R^{15})-, R^{15} represents a hydrogen atom, a linear or branched alkyl group having from 1 to 20 carbon atoms, or a linear or branched alkenyl group having from 2 to 20 carbon atoms, B^1 and B^2 each independently represents $-(CH_2)_p-(O)_q-(CH_2)_r-$, p and r each independently represents 0 or an integer of 1 to 3, q represents 0 or 1, Ar represents a monovalent aromatic group, a substituted monovalent aromatic group, a monovalent heterocyclic group or a substituted monovalent heterocyclic group, and M^+ represents a hydrogen ion, an alkali metal ion or a quaternary ammonium ion.

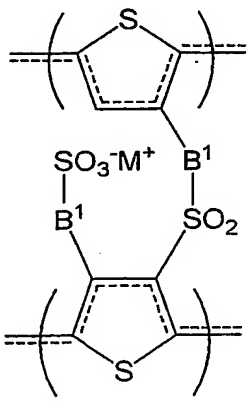
11. The self-doping type electrically conducting polymer as claimed in claim 10, wherein the crosslinked structure through a sulfone bond is a structure represented by formula (5)



(5)

wherein X represents -S-, -O- or -N(-R^{15})-, R^{15} represents a hydrogen atom, a linear or branched alkyl group having from 1 to 20 carbon atoms, or a linear or branched alkenyl group having from 2 to 20 carbon atoms, B^1 represents -$(CH_2)_p$-$(O)_q$-$(CH_2)_r$-, p and r each independently represents 0 or an integer of 1 to 3, q represents 0 or 1, and M^+ represents a hydrogen ion, an alkali metal ion or a quaternary ammonium ion.

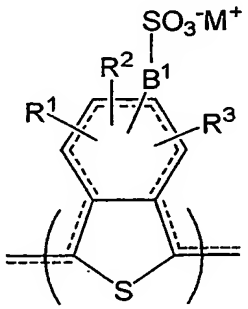
12. The self-doping type electrically conducting polymer as claimed in claim 11, wherein the crosslinked structure through a sulfone bond is a structure represented by formula (6)



(6)

wherein B^1 represents $-(CH_2)_p-(O)_q-(CH_2)_r-$, p and r each independently represents 0 or an integer of 1 to 3, q represents 0 or 1, and M^+ represents a hydrogen ion, an alkali metal ion or a quaternary ammonium ion.

13. A process for producing the self-doping type electrically conducting polymer containing a crosslinked structure through a sulfone bond represented by formula (2) described in claim 7, comprising dehydration-condensing self-doping type electrically conducting polymers having a structure represented by formula (7).

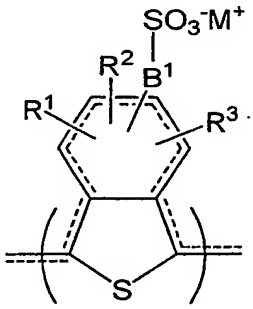


(7)

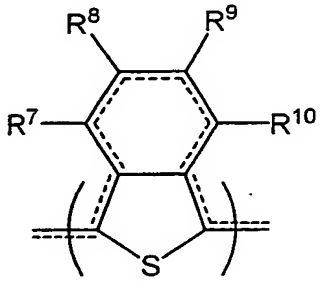
wherein R^1 to R^3 each independently represents a hydrogen atom, a linear or branched alkyl group having from 1 to 20 carbon atoms, a linear or branched alkoxy group having from 1 to 20 carbon atoms, a linear or branched alkenyl group having from 2 to 20 carbon atoms, a linear or branched alkenyloxy group having from 2 to 20 carbon atoms, a hydroxyl group, a halogen atom, a nitro group, a cyano group, a trihalomethyl group, a phenyl group, a substituted phenyl group or a $-B^1-SO_3^-M^+$ group, with the proviso that at least one of R^1 to R^3 is a hydrogen atom, B^1 represents $-(CH_2)_p-(O)_q-(CH_2)_r-$, p and r each

independently represents 0 or an integer of 1 to 3, q represents 0 or 1, and M^+ represents a hydrogen ion, an alkali metal ion or a quaternary ammonium ion.

14. A process for producing the self-doping type electrically conducting polymer containing a crosslinked structure through a sulfone bond represented by formula (2) described in claim 7, comprising dehydration-condensing self-doping type electrically conducting polymers having a structure represented by formula (7) and/or formula (8):



(7)

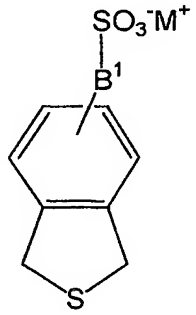


(8)

wherein R^1 to R^3 and R^7 to R^{10} each independently represents a hydrogen atom, a linear or branched alkyl group having from 1 to 20 carbon atoms, a linear or branched alkoxy group having from 1 to 20 carbon atoms, a linear or branched alkenyl group

having from 2 to 20 carbon atoms, a linear or branched alkenyloxy group having from 2 to 20 carbon atoms, a hydroxyl group, a halogen atom, a nitro group, a cyano group, a trihalomethyl group, a phenyl group, a substituted phenyl group or a $-B^1-SO_3^-M^+$ group, with the proviso that at least one of R^7 to R^{10} is a hydrogen atom, B^1 represents $-(CH_2)_p-(O)_q-(CH_2)_r-$, p and r each independently represents 0 or an integer of 1 to 3, q represents 0 or 1, and M^+ represents a hydrogen ion, an alkali metal ion or a quaternary ammonium ion.

15. A process for producing the self-doping type electrically conducting polymer containing a crosslinked structure through a sulfone bond represented by formula (3) described in claim 8, comprising dehydration-condensing self-doping type electrically conducting polymers obtained by (co)polymerizing a monomer represented by formula (9):

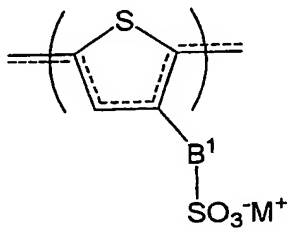


(9)

wherein B^1 represents $-(CH_2)_p-(O)_q-(CH_2)_r-$, p and r each independently represents 0 or an integer of 1 to 3, q represents 0 or 1, and M^+ represents a hydrogen ion, an alkali metal ion or a quaternary ammonium ion.

16. The process for producing a self-doping type electrically conducting polymer as claimed in any one of claims 13 to 15, wherein the dehydration condensation reaction is performed by a heat treatment at a temperature range of 210 to 350°C.

17. A process for producing the self-doping type electrically conducting polymer containing a crosslinked structure through a sulfone bond represented by formula (6) described in claim 12, the process comprising dehydration-condensing self-doping type electrically conducting polymers containing a structure represented by formula (10)

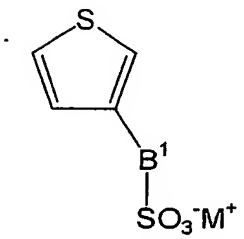


(10)

wherein B^1 represents $-(CH_2)_p-(O)_q-(CH_2)_r-$, p and r each independently represents 0 or an integer of 1 to 3, q represents 0 or 1, and M^+ represents a hydrogen ion, an alkali metal ion or a quaternary ammonium ion.

18. A process for producing the self-doping type electrically conducting polymer containing a crosslinked structure through a sulfone bond represented by formula (6) described in claim 12, comprising dehydration-condensing

self-doping type electrically conducting polymers obtained by (co)polymerizing a monomer represented by formula (11)



(11)

wherein B^1 represents $-(CH_2)_p-(O)_q-(CH_2)_r-$, p and r each independently represents 0 or an integer of 1 to 3, q represents 0 or 1, and M^+ represents a hydrogen ion, an alkali metal ion or a quaternary ammonium ion.

19. A self-doping type electrically conducting polymer obtained by the production process described in any one of claims 13 to 18.

20. An electrically conducting composition comprising the self-doping type electrically conducting polymer described in any one of 1 to claims 12 and 19, and a solvent.

21. A method for producing an electrically conducting film, comprising coating the electrically conducting composition described in claim 20 on a substrate and heating it.

22. The method for producing an electrically conducting film as claimed in claim 21, wherein the self-doping type electrically conducting polymer having a structure represented by formula (7) and/or formula (8) described in

claim 14 is applied onto a substrate surface and then the substrate is heated at a temperature of 210 to 350°C for 1 to 600 seconds.

23. The method for producing an electrically conducting film as claimed in claim 21, wherein the self-doping type electrically conducting polymer having a structure represented by formula (10) described in claim 17 is applied onto a substrate surface and then the substrate is heated at a temperature of 120 to 250°C for 1 to 600 seconds.

24. An electrically conducting film produced by the method described in any one of claims 21 to 23.

25. The electrically conducting film as described in claim 24, wherein the film thickness is from 1 to 1,000 nm.

26. A coated product comprising a shaped body having coated on the surface thereof the self-doping type electrically conducting polymer described in any one of claims 1 to 12 and 19.

27. A coated product comprising a substrate as a shaped body, wherein one surface, both surfaces or the entire surface of the substrate is coated with the self-doping type electrically conducting polymer described in any one of claims 1 to 12 and 19.

28. A coated product comprising a substrate as a shaped

body, wherein one surface, both surfaces or the entire surface of the substrate is coated with the electrically conducting composition described in claim 20.

29. The coated product as claimed in claim 27 or 28, wherein the substrate is a silicon wafer.

30. The coated product as claimed in claim 27 or 28, wherein the substrate is entirely or partially coated with indium tin oxide.

31. An electronic device comprising the self-doping type electrically conducting polymer described in any one of 1 to claims 12 and 19.

32. An electronic device comprising the electrically conducting composition described in claim 20.

33. An organic light-emitting element comprising at least one light-emitting layer between a pair of anode and cathode, wherein the self-doping type electrically conducting polymer described in any one of claims 1 to 12 and 19 is contained in the anode buffer layer.

34. The organic light-emitting element as claimed in claim 33, wherein the self-doping type electrically conducting polymer has a sulfonic acid group.

35. The organic light-emitting element as claimed in claim

33 or 34, wherein the self-doping type electrically conducting polymers are crosslinked through a sulfone bond.

36. An organic light-emitting element comprising the self-doping type electrically conducting polymer described in any one of 1 to claims 12 and 19.

37. An organic light-emitting element comprising the electrically conducting composition described in claim 20.

38. The organic light-emitting element as claimed in claim 33, wherein the light-emitting layer comprises a fluorescence-emitting polymer material.

39. The organic light-emitting element as claimed in 33, wherein the light-emitting layer comprises a phosphorescence-emitting polymer material.

40. An organic EL display comprising the organic light-emitting element described in any one of claims 33 to 39.

41. A display device for portable terminals, comprising the organic EL display described in claim 40.